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THE weights and measures, used for the simple traffic of original and primitive nations, are always of simple, and probably always of similar origin. The length of the human foot, or of the palm, or a pace, or a span, or the distance from point to point of the extended arms, are measures of

length most likely to occur at the early period of society; while, for capacity, the sewed skin of a domestic animal, and for weight, the weight of an ordinary ripe fruit or handful of grain, would afford a sufficiently accurate medium for the comparison of all exchanges necessary during the rude and pastoral age. But as civilization progresses, and as men become first agricultural, and then commercial, the necessity of fixing these relative values becomes more and more apparent, as well for the purpose of preventing frauds, as to ensure the results of trade, and render revenue, both public and private, certain and appreciable. It would also soon be discovered, that, in all civil commotions, the ordinary relations of value must, to a great extent, become subservient to factious purposes, and in this way abuses against the commonwealth be originated and continued. The Jack Cade of Shakspeare was no contemptible politician, when he ordained that "*there shall be*, in England, seven half-penny loaves *sold for a penny*, and the three-hooped pot shall have *ten hoops*." And in our own times, there have been found politicians of more faith and less conscience, who would have rendered tortuous the paths of public policy, by means not less direct than this.

Among infant nations, the standards of relative value are of course fluctuating and uncertain; the measures of capacity diminishing, in general, in proportion to the distance of the market from the place of manufacture, or of import; and the value of the monetary unit augmenting in an inverse proportion. An attention to fix and preserve these standards is the first evidence that the science of government is beginning to be understood; as, by judiciously controlling them, a nation gives certainty to its action, whether in peace or in war, prevents civil commotion, and can provide against any imposition of the higher upon the poorer classes. At the commencement of governments, when the first object of association is the security of the community, and war, of course, becomes the most honorable occupation, the civil authorities are always negligent of this function, and allow abuses to become fixed to an extent so vicious, as to be remediless, without severely wounding the commercial interest, depreciating the revenue, or hazarding a revolution, and disorganization of the State. And this being the case, we shall always observe, that in nations which have advanced regularly from barbarism to civilization, the era in their annals

marked by the greatest attention to the regulation of standard values, is always that of the greatest prosperity and refinement.

In England, the first serious attention to this subject seems to have been given in the year 1266, (in the reign of Henry III.,) when, "by the consent of the whole realm of England, the measure of our lord, the king, was made; that is to say, that an English penny, called a sterling, round, without clipping, shall weigh thirty-two wheat corns in the midst of the ear; and twenty pence to make an ounce, and twelve ounces one pound, and eight pounds do make a gallon of wine; and eight gallons of wine do make a London bushel, which is the eighth part of a quarter." This statute, which was afterwards copied into that of the thirty-first year of Edward I., (1303,) has been the basis of the present system of weight and measure in England, from which the standards in use among us have been derived. We may learn, from its provisions, without further authority, that at this period coin was taken by weight, and not by tale; a heavy grievance to the common people, when the standard of weight was so ill defined. We may also infer, that the English were still a warlike, something of an agricultural, but not yet beginning to be a manufacturing people; for had they then attained to any degree of the latter quality, the unit of length must at least have been mentioned. It is also evident from this statute, that, at this time, the ale and domestic spirit of the country had not yet become an article of commerce, as the gallon, or measure of liquid, is defined by the weight of wine. There may, to be sure, be some doubt of this, as at that time ale may have been measured by the bushel; the French *boisseau*, from which our word "bushel" is derived, indicating, by its termination, rather a wet than a dry measure.

The measure of length was not defined till the seventeenth year of Edward II. (1324), when it was ordained that "three barley-corns, round and dry, make one inch; twelve inches one foot; three feet a yard," [*ulnam*,] &c. But there was no attempt to connect the measure of length with the measure of capacity, till the thirteenth year of William III. (1701). The statute of that date declares, that "the Winchester bushel shall be round, with a plane bottom, eighteen and a half inches wide throughout, and eight inches deep." By an act of the following reign, a wine gallon, originally the

eighth of a bushel, is declared to be a cylinder, seven inches in diameter and six inches deep, containing two hundred and thirty-one cubic inches.

The history of the introduction of the wine gallon among English measures is an example of the manner in which standards are deteriorated and corrupted, unless preserved by a strict surveillance on the part of the government. We have seen that, by the statute of Henry III., but one gallon is acknowledged throughout the kingdom, and this, too, called a gallon of wine. Yet it was discovered, about the year 1680, that it had long been customary to sell wine by a gallon varying from two hundred and twenty-four to two hundred and thirty-one cubic inches. In this way, the importers of wine paid duties on a gallon of two hundred and seventy-two to two hundred and eighty-two cubic inches, and sold by one of a capacity nearly one fifth less. And so fixed had this abuse become, that a special law was obliged to be passed, in the fifth year of Anne (1705), by which the wine gallon of two hundred and thirty-one inches is, for the first time, recognised as one of the standards of England. The original of the wine gallon, said to have contained about two hundred and twenty-four cubic inches, had been kept at Guildhall by the merchants of London. In relation to the discovery of this heterodox standard of the English vintners, there is something at once ludicrous and grave in the following extract from a report of a Committee of the House of Commons, in 1758.

"Your Committee observing that, by the evidence of the gaugers, the ale and beer gallon contained 282 cubical inches; and finding that, by all the statutes, down to the 5th of Queen Anne, wherever wine measure is mentioned, the legal standard gallon of the Exchequer is referred to, or understood; endeavoured to discover for what reason the wine gallon was reduced 51 cubical inches; viz. from 282 to 231. And upon inquiry of the Commissioners of the Excise, they communicated to your Committee, copies from their books, of a memorial from the Commissioners of Excise and Hearth Money, to the Commissioners of the Treasury, dated the 15th of May, 1688;* setting forth that all beer and ale had been gauged at 282 cubical inches, for the gallon, and other exciseable liquors, according to the supposed wine gallon at 231 cubical inches; but being informed, that the true standard wine gallon, ought to contain only 224 cubical

* Appendix 2. Report from Committee of the Commons. 1814.

inches, they had applied to the Auditor and Chamberlains of the Exchequer, to examine the standard measures in their custody, and, upon examination, they found three standard gallons, one of Henry the Seventh, and two of 1601, which an able artist, employed by them, had found to contain, each 272 cubical inches; that, finding no wine gallon at the Exchequer, they had applied to the Guildhall of the city of London, where they were informed, the true standard of the wine gallon was; and they had found, by the said artist, that the same contained 224 cubical inches only; and they further represent, that the gallons of the other parts of the kingdom, used for wine, had been made and taken from the said Guildhall gallon.

"In consequence of this memorial, the Lords of the Treasury, the 21st of May, 1688, directed an authority to be drawn, for gauging according to the Guildhall gallon, which was accordingly done; but it does not appear that such authority was ever signed.

"After this direction, it appears that several merchants applied, that his majesty would be pleased to empower the merchants to sell as they were gauged, that is, according to 224 cubical inches to the gallon. * And the Commissioners of the Customs not following the new proposed method of gauging, upon the 12th of June, 1688, Sir Thomas Powis his opinion is taken upon it, in which he says, 'that having considered the proposal of the Commissioners of the Excise, concerning the gauging of exciseable liquors, and perused the acts of Parliament relating thereto, he cannot advise the prosecuting the proposal in regard of the hazard attending it; for if the usage of gauging be departed from, he knows not where we shall be, because resort cannot be had to the Exchequer for a standard, to which almost all the statutes refer, for there is none there but what the king will be vastly a loser by; secondly, Guildhall cannot be resorted to for a standard, for no law or statute refers to it.' "

We shall have some idea of the difficulty of preserving the relative value, in a system of standards, derived from the primitive usages of any nation, when we are aware, that in England, between the reigns of Henry III. and George II.,

* From this we should infer, that the merchants were gauged by a gallon of 224 inches. This was not the case. For in a suit brought, in 1699, against Thomas Barker, for having paid duties by the gallon, of 282 inches, instead of the ordinary wine gallon, the defence set up was, that the true standard of the kingdom was the gallon of the Exchequer, whereupon the Attorney-General agreed to withdraw a juror. The failure of this prosecution produced the act of 1705.

thirty-nine distinct statutes had been passed, with the constant purpose of ascertaining and regulating the weights and measures of the kingdom; and yet, that so late as 1758, when the subject was first properly considered in the national legislature, a Committee of the House of Commons gave the following account of the anomalies and discrepancies, existing among the Exchequer standards.

"Your Committee observe, that if the standard bushel is to be taken from that remaining in the Exchequer, then it contains twenty-six cubical inches less than the bushel ought to contain, according to the dimensions, established by the act of King William, which is 2150 cubical inches; and, according to the size of the bushel, the gallon, or eighth part of it, should contain 265½ cubical inches, which is less, by five cubical inches and a half, than the standard gallon of the Exchequer; and the quart ought to contain 66·375 cubical inches, which is near four cubical inches less than the standard quart; the pint should contain 33.1875 cubical inches, whereas the standard pint contains 34·8 cubical inches.

"But as, by law, the bushel ought to contain eight gallons, if the standard gallon of the Exchequer be eight times filled, the contents of the whole will be 2168 cubical inches to the bushel, which is forty-four cubical inches more than the bushel used as a standard at the Exchequer." *

The provisions of many of the statutes, passed within the interval above mentioned, when the science of the country was not sufficiently advanced to come in aid of the civil authority, tended, in most cases, to increase the confusion and uncertainty. As instances of this, we may notice the liberties taken with the standard yard. By the statute of the fifteenth year of Henry VI., the *Aulneger*, or measurer of ells, is directed "to procure, for his own use, a cord twelve yards and twelve inches long, adding a quarter of an inch to each quarter of a yard." This statute marks the era, when the woollen manufacture had begun to be important, the provision being intended to make certain the hitherto vague custom of allowing the breadth of a thumb to each yard of woollen cloth, for shrinking. In the fourth year of Richard III., as if in contravention of this statute of the thumb, it is ordained, that "cloths shall be wetted before they are measured, and not again stretched." But in the tenth year of Anne,

* Appendix 2. Report from Committee of the Commons. 1814.

the elder statute is again followed, and it is enacted, that "each yard is to have an inch added to it, instead of that which is commonly called a thumb's breadth." These laws show the usual progress of legislation on such subjects, the most striking instance and specimen of which is perhaps found in the statute of the thirteenth year of Richard II., where unity of weights and measures is ordained throughout the kingdom, "except it be in the county of Lancaster, because in that county it hath always been used to have greater measure, than in any other part of the realm."

We have taken the example of the English nation, to show the ordinary course of legislation, as to standard values, because it will be found, with differences merely of denomination, to have been the history of similar changes, in every other country; and because the English measures, being synonymous with those in use among us, seemed, on that account, more applicable to a notice of the subject, as it presents itself here. That it is no easy matter to remedy abuses of this nature, will be evident from the fact, that, during six centuries, the English people, having constantly the same aim, to wit, that weight and measure should be uniform, have scarce yet reached their object; and, in attaining to the comparative certainty, which they at present possess, have been obliged to tolerate frauds and vexations, which were only discovered, after they had become fixed by prescription, and past cure; for "there is no custom, regulation, or institute in civil society, so difficult to be altered, as an established system of weights and measures, except, indeed, the language of a country." *

But if the progress of this matter in England should be of interest to us, as exhibiting the gradual changes, which are induced in the standards of an established government, while undisturbed and at peace, the operations in France are of still more interest, as showing what may at once be achieved by a nation, while in the act of changing the form of its civil institutions. In France, a radical change of the system of weight and measure was commenced, a project which could only have been successful during a state of revolution. We may conceive, when the decimal system was first promulgated in France, and the ancient measures declared to be illegal,

* Evidence on the Glasgow petition.

that the mere mention of the toise, the louis, or the livre, would have been a political heresy, to be expiated only on the guillotine. As this was a measure, brought forward by the first national assembly, it was throughout considered as republican in its tendency, and, with few exceptions, gave an immunity to all those concerned in it. The new system therefore acquired a strength from the period in which it was proposed. It gave the young republicans another test, another sacrament in the new ritual. Had an interval of two years elapsed, the success of the experiment in France would, at least, have been questionable. And, in view of these facts, and being aware, from the examples of other nations, how difficult it is to change an establishment, even after it has become confessedly vicious, we should be better able to estimate, in a young country like our own, how important it is, to commence right, and adopt a convenient and well-arranged system at first. It has been said, that the evil arising from incongruity and uncertainty of measures, is "more imaginary than real; more felt by philosophers, than farmers, or others interested in practice; for as the contents of customary measures are generally known to all persons concerned in their use, the prices are regulated accordingly."* We do not believe this. Standard measures may indeed not be necessary to the large corn factors, or farmers, or merchants, in their dealings with each other; but they are not the less indispensable, to protect the lower and middle classes, the consumers in detail, from uncertainties and vexations, which it is the duty of every well-constituted government to avoid and prevent. The English corn factors, however, though they prefer to have in their own country as many different bushels as possible, admit, that in a colony, or a new country, the simpler and more unique the measure, the better.

The attention which had been given to this subject, both in France and in England, induced, at length, a proper consideration of it here. The federal constitution has made it one of the functions of the general government; and the proper establishment to be made was frequently discussed during the presidency of General Washington, and at his special call. At length, upon finding a diversity of standards of the same denomination, throughout the country, it was determined that

* Dr. Kelly's Evidence on the petition from Glasgow.

the standard to be adopted should be a mean of those then in use, and here the subject was suffered to rest for a long time. By repeated examinations and comparisons of the value and origin of the weights and measures, in general use, they were all found to have emanated from the English standards, of which scattered traces were to be found, in different parts of the country. The report of Mr. Adams upon that subject, in 1821, showed how much variety and uncertainty had been introduced by the lapse of time, and the want of proper standards. The great amount of the dealings of the government with its citizens at the custom-houses, and the legal stipulation, that the duties shall be uniform, produced, in 1830, a resolution of the Senate, directing the Treasury department to have a full and accurate comparison made, of all the weights and measures in use among the officers of the revenue. The execution of this comparison was confided to F. R. Hassler, Esq., who, in 1832, made an extensive report upon the subject, which is document 299, of the printed documents of that year. In consequence, Congress, in 1834, directed the Treasury department to have standards constructed for the several custom-houses. These standards are now in progress, under the superintendence of Mr. Hassler. *

Before, however, noticing the origin and execution of these standards, which are of course of more interest to us, than the measures of foreign nations, it may not be amiss to take a brief review of the more recent improvements in construction, and the various legislative acts of the elder countries; and to say something of the manner in which standards were defined and compared, when they first came to be considered by men of science.

In England, the parliamentary investigation of this subject, which lasted from 1758 to 1765, deserves notice more as having first directed the attention of the public to the diversity of standards then in use, and the inefficacy of the numerous laws enacted for their preservation, than for having provided any effectual remedy for the existing evils. The Report of the Committee of 1758 and 1759 is, however, characterized by soundness of view, and distinctness of purpose. They deprecate the existing diversity of standards;

* This paragraph is repeated, from a notice of the subject, in the National Gazette of June 9th, 1836.

and propose, that the yard of the Exchequer, as derived from a copy formerly made by Graham, for the Royal Society, should be made the unit of length; and that the ale gallon be taken as the base, for all measures of capacity. This report, in consequence of the prorogation of Parliament, was not acted upon; though a bill had been introduced, in conformity with its recommendations. The Committee also presented, with their Report, two copies of the yard of the Royal Society, made by Bird, with the extremities of the yard marked by dots on gold pins. One of these was sent to the receipt of the Exchequer, and the other (usually known as the parliamentary standard) delivered to the clerk of the House. This standard was in existence, until the fire of 1834, which destroyed the two houses of parliament. It had, previous to that accident, been accurately compared with the metre, and other measures, in the possession of scientific individuals; so that its value, even after its destruction, may be considered as very well ascertained. At this period, neither the Committee, nor any of the scientific persons, whom they consulted, seem to have thought of the possibility of fixing a standard of length, by comparison with any natural measure, or constant quantity, which could always be determined by some law of physics; but expressly state, that the measure of length "cannot be described in words, but by reference to some determined space, of which a model, or standard, is previously established." The labors of this Committee, though unsanctioned by the legislature, and producing no practical change or improvement, were nevertheless of much use, as showing that while the standards kept at the Exchequer, under the custody of the government, had from misuse and neglect become bent and uncertain, copies of the same pieces made by the Royal Society, for their own use, were still in good preservation, and might be relied on as authentic; thus directing the attention of the nation to their highest scientific institution, as the surest agent both to determine and preserve this species of evidence.

We are inclined to think, though it appears nowhere distinctly among the documents of that period, that the parliamentary investigation of 1758 – 1765 was intended mainly to restore the ale gallon, of two hundred and eighty-two cubic inches, as the standard upon which all the measures of capacity in the kingdom ought of right to be based; and that the

project had grown out of the then commencing rivalry between the ports of Liverpool and London. The Lancashire measures being larger than those of London, and some of the London measures but very recently acknowledged to be legal, commercial jealousy would naturally seize upon this discrepancy, as a matter which might be turned to account. However this may have been, no law was then passed on the subject, and the matter rested till 1814. In the mean time, the French, being at once in a state of revolution and of war, began *de novo*.

The precise state of the French measures, previous to the revolution, does not now appear. That they were uncertain, incongruous, and imperfectly authenticated, may be inferred from the fact, that, under the monarchy, the subject had been repeatedly pressed upon the consideration of the government. Delambre, in his Preliminary Discourse, mentions it as a long existing evil. "The astonishing and scandalous want of uniformity in our measures," says he, "had long been a subject of complaint, with good men. More than once, propositions of reform had been submitted to the government, who had caused them to be examined. But, notwithstanding the favor of the ministers, and particularly of Orry, Controller General of the Finances, these propositions had always been rejected or forgotten." * The subject of a new system was first moved in the National Assembly by Talleyrand. Among the many important functions which this individual has been called upon to discharge, in the course of his long and eventful life, there can, we suppose, be but few, which have produced more important results than this. It gave a new and bloodless field to the energies of the *esprits forts*, which were then beginning to show themselves in France, which was to make her wars useful and illustrate her trophies.

The decree of the National Assembly is of May 8th, 1790; and the Proclamation of the King, of August 22d, of the same year. It ordains an exhibition of the old measures, but contemplates, for the basis of the new system, the length of a pendulum vibrating seconds, in the mean latitude of 45°. This determination the King is desired to make, in conjunction with England, and by a commission, consisting of an equal number of members of the Royal Society of London,

* Base du Système Métrique. Tome I. page 13.

and of the French Academy of Sciences. But, at this time, there was less of friendly feeling between the two countries, than had ever existed before. The English academicians would have regarded with horror, as well as doubt, any result derived from the most palpable premises, which could have been produced by Frenchmen. If report were not so often a romancer, we should have to suppose, that the same aversion obtains to a great extent still. When it was not long since suggested to a distinguished British astronomer, that some of the discrepancies of the trigonometrical survey of England might be reconciled by adopting a different ellipticity for the terrestrial spheriod, the patriotic philosopher is said to have replied; "I know it; but to do so, we must take the ellipticity of the French."

It does not appear distinctly, what measures were taken under the law of 1790. But the project was changed by the decree of the ensuing year, (March 30th, 1791,) which adopts the quarter of the terrestrial meridian, as the base of lineal measure; the ten-millionth part of it to be called the metre. It also directs that, to determine the value of this unit, the arc of the meridian, from Dunkirk to Barcelona, shall be measured. The measures of weight and capacity are connected with the unit of length, by being made the area, or the weight of distilled water at the maximum density, of submultiples of the metre. The Commission, appointed to execute the new measure, comprised a mass of talent, which has rarely, either before or since, been brought to bear on any one project. Borda, Prony, Mechain, La Lande, Delambre, La Place, Lavoisier, and Monge, were all named; the measure of the arc being confided to Mechain and Delambre. This operation was commenced in 1792, and had been prosecuted with zeal and success, for more than a year, when it was interrupted by a decree of the Committee of Public Safety. This decree, which is dated 3d Nivose, An. 3, and authenticated by the signatures of Barras, Robespierre, Billaud Varrenne, Couthon, and Collot d'Herbois, is a singular document, both as showing how, in times of political commotion, the most useful projects are made to share the fates of their patrons, and how necessary it is to control and give occupation to the force, which a revolution always developes. The project of the Academy of Sciences, recommending that the quarter of the meridian should be taken as

the lineal unit, had been adopted by the republicans, as part of the policy, which was intended to destroy all the ancient modes, and names, and usages of the kingdom. The Academy, not wishing to trust the previous measurement, directed a new triangulation over a larger arc. This had been in progress for little more than a year, and had been conducted not only with ability, but with zeal; yet the agitators were afraid, lest it might not give results speedy enough, to answer as food for the public excitement. They therefore suppress the Commission, and decree, as a provisional and proximate measure, that the quarter of the meridian shall consist of 5,132,430 toises, and that the metre, or ten-millionth part of it, shall be three French feet and 11·44 lines. Upon this lineal unit, a system of measures, both of weight and capacity, was instituted, and a temporary agency appointed, to construct the standards necessary for the republic. Had standards been fabricated according to this decree, the French system would have been vicious from the beginning. The object of this manœuvre was, however, not purely scientific, — it was meant to direct public opprobrium upon certain members of the Academy, who were either inimical or temperate; and it was, perhaps, in consequence of this, that certain of them suffered in the severe proscription which followed. The decree is given at length by Delambre. It sequestrates (*destitue*) Borda, Lavoisier, La Place, Coulomb, Brisson, and Delambre, and requires the remaining members of the Commission to put the Committee in possession of "their views, respecting the method of giving the benefit of the new measures to all the citizens as soon as possible, taking advantage of the revolutionary movement." Upon which Delambre gravely remarks; "they thus wished to take advantage of the revolutionary movement; and it was a very good idea; but perhaps it was not impossible to arrive, by other ways, at the same results."

In 1794, on the report of C. A. Prieur, the measure of the arc was resumed by the former superintendents; and, as a general Commission on weights and measures, there were appointed Berthollet, Borda, Brisson, Coulomb, Delambre, Haüy, La Grange, La Place, Mechain, Monge, Prony, and Vaudermonde. The measure of the arc was completed in 1797, giving the length of the quarter of the meridian at 5130740 toises, and that of the metre, 443″·295936 French

ligus, or 39·382755 English inches. As this metre differed from the provisional measure, adopted in 1793, the latter was revoked and declared illegal, and new standards were directed to be executed, in conformity with the new determination. These were introduced gradually into department after department, until the year 1804, when they were in general use throughout the kingdom. They continued undisturbed till 1812, when Napoleon, either because he thought the decimal system too republican to suit the empire, or because it actually occasioned some complaints, by an imperial decree of 1812, ordained that the double metre should be called the toise, one third of a metre the foot, and twelve decimetres the ell. The bushel was made a fourth of the hectolitre, and the pound equal to five hundred grammes. During the revolution, an entire new system had been carried out with a high hand; but when the fever began to subside, Messieurs les Français were found prone to say twenty metres, instead of two decimetres. They discovered, that, in arithmetic as in love, it is necessary to prefer binary combinations; and the names of the old system returned in functions of the new.

In the mean time, however, the new system had become too firmly established, to be shaken even by an imperial decree. The toise, and other imperial measures, are rarely mentioned in France; and even on the promulgation of the decree, the Minister of the Interior (Montalivet) found it necessary to make stated answers to nine several objections against any change of denomination, which had been simultaneously forwarded to his bureau, from different parts of the kingdom. There is some sophistry in the responses of the minister, as we may infer from the following instances. "The names given to measures, in conformity with the newly adopted principles, did not, perhaps, harmonize with the character of the language, by reason of their length, their too great similarity, and the uniformity of their terminations." And again, it is rather a slander on the intelligence of the great nation, to say; "this division, very favorable, no doubt, to the processes of calculation, offers no advantage to the people, who are not accustomed to calculate, and ought not to be compelled to do so."*

There are some peculiarities of the French standards,

* Circular of the Minister of the Interior. July 10, 1812.

which it may be of interest briefly to notice. It has been customary, in most countries, to have standards, and the measures for common use, made of brass, as being a compound less liable to oxidation than others. It has, however, this objection; that as the compounds which may be designated as brass are very numerous, and of different expansibilities, standards made of this metal would be uncertain and not comparable. To avoid this objection, the republican standards were made of simple metals; of platinum, and of iron. Indeed, so attentive were they to this condition, that though the original metre and killogramme be of platinum, yet on discovering, that, from the mode of manufacturing this metal, its density must be devious, and of course its expansion different in different pieces, they preferred the metre of iron as the more certain. The standard temperature had also been taken usually, at the mean temperature of the climate; in England it is 62°. of Fahrenheit. The French made their standard temperature, that of melting ice, which is a fixed point of the thermometer; and for weight and capacity, they adopted the weight or quantity of distilled water, at its maximum density. The English, in their new standards, seem to have thought the advantage of a simple metal, and a temperature independent of the graduation of the thermometer, not worth consideration. Indeed, for their standards of weight and capacity, they have taken a metal of three or more components, which Captain Kater recommends, in one place, because it is nearly the color of gold; and, in another, because it is less liable to oxidization in the climate of England.

The greatest service, however, which the French have done to the world in this matter, is, in having connected the units of measure of weight and capacity by certain relations, which can always be identified, making the unit of capacity the cube of an aliquot part of the lineal unit, and the unit of weight, the weight of a cube of distilled water, (also an aliquot part of the lineal unit,) at its maximum density. They have succeeded in fixing and bringing into use, the best system of weights and measures yet known. The metre, throughout the continent, is already the medium of comparison between the lineal measures of different nations, verifying the hopes of its projectors, that it might, in time, come to be an universal measure. The original metre

and kilogramme in platinum were delivered in 1799, upon which a decree, signed by Sièyes, Bonaparte, and Roger Ducos, directs that a medal shall be struck to commemorate the event, having on its principal face, the inscription, "À tous les temps, à tous les peuples;" and on the reverse, "République Française, An. VIII." The Consuls are dead, and two of them well nigh forgotten. The republic, and the empire which followed it, are no more. But the new domain, gained to science by their patronage, has been preserved, and given even to them a more imperishable monument, than fields or kingdoms, whether lost or won.

In England, from 1760 to 1814, the inattention of the government had been supplied by private exertion. Sir George Evelyn Shuckburg had devoted his time and resources to the subject of fixing standards. He procured from the late celebrated artist Troughton, a scale by which he made comparisons of the several lineal measures, then known in England. This scale, together with others made by the same artist, has since been much referred to, in establishing the relative values of different standards made in earlier times. Sir George Shuckburg extended his researches further, to determining the weight of fluids, and also the length of the pendulum of seconds. And though, as might have been expected, the results of his experiments have since been discovered to be inaccurate, owing to the neglect of certain influences, which were then held to be inappreciable, still they attracted public attention to the subject, and prepared the way for more perfect determinations.

The parliament resumed the consideration of the subject in 1814, with the advantage of all the experience, which private enterprise had acquired for them, and which the progress of the new system had developed in France. They began by inquiring for an uniform standard in nature; some measure which could always be detected, or known by some universal law, independent of any piece or model, by which it might have at any time been defined. To this end, a Committee of the House of Commons examined Prof. Playfair and Dr. Wollaston, who agreed that the pendulum, vibrating seconds in any given latitude, would be the best standard of lineal measure, and that any other unit, which the usage of earlier times might have made it advisable to adopt, could always be identified by its relation to this. The

opinion of these two distinguished men shows, that, at this period, the requisite attention had not yet been given to this subject in England, as subsequent researches have made to appear. It has been found that it is no easy matter to determine the precise length of the pendulum, vibrating seconds in any latitude; and also that difference of formation, and irregularity, either in the shape of the surface, or its density, have perceptible influence. And even admitting the length of the second pendulum in the same latitude, to be a constant quantity, and that its relation to the yard be known, the yard, if lost, would not be recoverable from the pendulum, as one is not an aliquot part of the other. Had the English, therefore, meant to verify their yard by the pendulum of seconds, it would have been advisable to make the yard $\frac{1}{1}\frac{2}{3}$ of the pendulum, which would have lengthened it about 0·12768 of an inch.

The Committee of 1814 recommend, that the parliamentary standard of 1758 be adopted as the lineal unit, and the Troy pound as the weight from which all others are to be derived. They advance divers reasons for this recommendation; the first being, that Troy weight is really London weight, that metropolis having been sometime known as Troy-Novant. They further recommend the Troy pound, because it has always been used among goldsmiths, at the mint, and by the faculty of medicine. They further propose that the avoirdupois pound be made equal to seven thousand troy grains, and that both weights be fixed, by making a thousand ounces avoirdupois equal to the weight of a cubic foot of water, at the temperature of 56½° Fahrenheit; the gallon to be made equal to ten pounds avoirdupois of distilled water, at the same temperature.

In furtherance of these views, the Prince Regent, in 1819, appointed a Commission consisting of Sir Joseph Banks, Sir George Clerc, Davies Gilbert, Dr. Wollaston, Dr. T. Young, and Captain Kater, to take the project into consideration. Previous to this, Captain Kater had made experiments on the length of the pendulum in the latitude of London, and had compared the metre with the standard of 1760. The result of these gave the metre 39·37079 English inches, and the second pendulum in the latitude of London, at the level of the sea, 39·13842 English inches, of the parliamentary standard. The Commissioners, in their first

Report, advise the adoption of the yard used by General Roy, in the trigonometrical survey of England. But, subsequently, having discovered, very unexpectedly, that this was not properly authenticated, they propose the parliamentary standard. This standard, imperfectly constructed at first, had been so much deteriorated by frequent use, that the points determining its length, resembled under the microscope "the miniature craters of small volcanoes," and no two persons could agree in bisecting them with sufficient accuracy to make correspondent results.

The standards proposed by the Commissioners for measures of capacity, would seem not to be defined with the necessary accuracy. They recommend, "that the ale and corn gallon be restored to their original equality, by taking, for the statutable common gallon of the British empire, a mean value, such that a gallon of common water may weigh ten pounds avoirdupois in ordinary circumstances, its contents being nearly 277·3 cubic inches."* These values were approved, and a law passed in 1824, directing the construction of models in conformity with them, the final adjustment of which was intrusted to Captain Kater. We have an account of these standards, in the Philosophical Transactions for 1826. There appears, however, to have been some *gaucherie* in their final adjustment, as may be inferred from the paper of Captain Kater, in the Transactions for 1830; "On the Error in Standards, arising from the Thickness of the Bar, on which they are traced." In 1834, the Bird standard was destroyed by fire; not, however, till Captain Kater's copies had been investigated by Bailly and others, who were engaged in making a new standard for the Astronomical Society. Mr. Bailly's paper, published in the Memoirs of the Astronomical Society for 1836, gives a minute description of this standard, of which several copies have been made; and also a detail of its value, as compared with the most important of its contemporaries. This standard is of a peculiar construction, which it may be well enough to describe. It is a cylindrical tube 0·19 of an inch thick, and with an exterior diameter of 1·12 inches. The cylinder is, however, not solid, but consists of two tubes, each of the thickness of ·05 of an inch, drawn into an exterior tube of the thickness

* Third Report of the Commissioners of Weights and Measures.

of 0·1 of an inch. The tube is sixty-three inches in length, and has a brass plug in each end. It is supported on two rollers, at a quarter of its length from each end, to equilibrate the weight and allow free expansion. The graduation is made on platinum pins, on four lines, at equal distances from each other, on the surface of the tube, so that there are four different standards united; the middle yard of the scale being taken as the true one.

This construction was probably adopted, on account of the difficulty found in supporting flat bars in the same plane. But it is questionable, whether a greater evil is not produced, than the one which it was intended to remedy. For though the tube, being supported at a fourth of its length from each end, be nearly in equilibrio, this does not prevent flexure, and the *flèche* will be greater, in proportion to the time during which the apparatus shall be left in the same position. When the brass plugs were taken out of the ends of the tube, its length was reduced 0·88 of the micrometer, or 0·00044 of an inch. But whatever rank this standard may take, the history of the preservation of the measure, which it is intended to represent, proves conclusively, that the custody of such matters is always appropriately intrusted to learned societies, in preference to the ordinary functionaries of the government. The English standards, kept at the Exchequer, were all vicious and uncertain; and it is only through the agency of the Royal Society, patronizing the labors of Graham, Bird, Troughton, Simms, and other distinguished artists, that the original English yard can be traced approximately, even as far back as 1750. This consideration should not be lost sight of in this country. The copies of standards, given to custom-house officers for use, will not long remain perfect; and it will be only by intrusting them to the keeping of universities, or learned societies, that we can expect to have them preserved. It is to be regretted, that the English standard yard is not that of the trigonometrical survey. If this had been the case, the union of the French with the English survey, which has recently been effected, would have given the ratio of the different measures on some line common to both operations.

The metre is at present the common measure of Europe. The celebrated Bessel has, for some time, been employed in constructing the standard for Prussia. To detail, however,

all the similar operations, in different countries, would extend this paper beyond its proper limit. We will, therefore, briefly state what has been done among us.

Though, for a long time, the several recommendations from the Executive had pressed upon Congress the necessity of remedying the inconveniences, already produced by so long a neglect, yet it was not till 1830, that, by a resolution of the Senate, the Treasury department was authorized to have an accurate comparison made, of all the weights and measures then in use at the several receipts of revenue. The President appointed Professor Hassler to this duty, who, having collected, not only from the different custom-houses, but from other quarters, all the measures which were attainable, instituted and completed an elaborate comparison, the results of which are stated in the Report of 1832.

The measures of length, sent from different places, did not deserve the name of standards. A brass yard, cut to length, from the office of the Secretary of State of New York, and a scale of forty inches, by Gilbert, from the University of Virginia, were the most authentic. But this defect was supplied by standards, procured from the state, Treasury, and Engineer departments, and from the *appareil*, procured in 1815, for the survey of the coast. Copies of the English yard and ell by Thomas Jones, two iron toises by Canivet, nine metres, of iron, platinum, and brass, (one being an original, delivered by the Committee of Weights and Measures, and another standarded by Arago,) were procured from these sources. But the most important measure, was a brass scale of Troughton, of eighty-two inches in length, with an arrangement for comparison, which was made for the survey of the coast. Indeed, without this scale, or one of a similar construction, the accurate comparison of the other measures could not have been made at all. This scale is also of more value, as by it we are made certain, that the yard, adopted as a standard, is, as nearly as possible, identical with the British imperial standard, which is intended to be a copy of the standard of 1750. In addition to this, one of the pieces contains the distance of 51·2 inches, from the scale of Shuckburg, and another, a copy of the yard of 1750, laid off by Troughton, on platinum dots. The details of the comparison are of much interest, as showing the extreme accuracy attainable, by the

scientific means of the present day. We will merely state the final results of the comparison of the metres, in inches of this scale, at the temperature of 32 Fahrenheit.

Platinum metre, 39·38042103 inches.

Iron metres,	39·3808643
	39·3807828
	39·3799120
Brass metres,	39·37981476
	39·3795982
	39·3804469

These determinations differ imperceptibly from those of other metres, made with the English scales. And, in the present state of science, it is more the object to determine the relative value of the several pieces, than to attempt precise copies of any. Indeed, the modes of comparing are superior to those of construction, as will be evident from the following statement of Mr. Bailly, of the relation between several of the recent standards. The last made standard of the Astronomical Society, is longer than the

Imperial standard,	0·000377 of an inch.
Copy made for Russia,	0·000456
Copy made for Denmark,	0·000125
Scale of Shuckburg,	0·000058

Of the weights furnished from the custom-houses, the resulting pounds differed, in the extremes, two hundred and forty-six troy grains; but in general, did not vary more than five grains from the standard. They were compared with a set of grain weights of Troughton, furnished for the coast survey in 1815. These grain weights were compared with a pound troy, made by Troughton, and brought to this country by Mr. Hassler, in 1805, and agreed with it. This pound troy, of 1805, was found, however, to differ from the pound troy of the United States' Mint, which had been standarded by Captain Kater, in 1828, being 2·38 grains lighter. It had been discovered previously, by Sir George Shuckburg, that the standard troy pound of 1758 weighed 5763·817 Troughton grains; and it is now ascertained that the pound of the United States' Mint has lost weight for about 1·2 grains by use. These English weights were also compared with the kilogram and other foreign weights. The

details are of much interest; but to notice them even summarily would overpass our limits. The main results are these;

Troy pound of 1758 (by Sir G. Shuckburg) in Troughton grains,	5763·73
Troy pound of United States' Mint (F. R. Hassler)	5762·38
Kilogram original, (F. R. Hassler)	15439·619
Kilogram original, (certified by Minister of the Interior)	15432·719

In making these comparisons, there being no means of procuring, without great loss of time, balances of sufficient delicacy, Mr. Hassler used water and mercurial balances, on the principle of the hydrometer, which are more sensible, and have no friction.

The measures of capacity collected, were more discrepant than those of length or of weight. Of forty-eight bushels, sent from the different custom-houses, the extremes were found to differ in contents, four hundred and thirty-three cubic inches. Yet the indiscriminate mean of the whole gave two thousand one hundred and fifty-three cubic inches, differing only 2·18 inches from the English Winchester bushel, from which they had, doubtless, been first derived. The following were the nearest, and the most remote, from the original.

	Contents.	*Weight.*
Bushel from Bath, (Me.)	1925· cub. inches.	74·2
Portsmouth,	2153·74	77·12
Newburyport,	2150·52	
New York,	2152·36	78·13
Georgetown,	2152.60	
Cherry Stone,	2225.48	83.4

On the completion of this comparison, the government adopted for the different kinds of standards, the following bases; viz. the unit called the yard to be the mean thirty-six inches, from the scale of Troughton; the troy pound of the mint, to be the basis for determining the unit of weight; the British Winchester bushel, of 2150·4 cubic inches, equal to 77·6274 pounds avoirdupois of distilled water, at the maximum density, to be the unit of dry measure; and the English wine gallon, of two hundred and thirty-one cubic inches, equal to 8·339 pounds avoirdupois of distilled water,

at the maximum density, the unit for liquid measure. This establishment was the last official act of Mr. Ingham, as Secretary of the Treasury.

Professor Hassler has used brass as the metal for all the standards of this country; the reason given being, that, as the copies for common use would naturally be made of this compound, (it being the cheapest and least liable to oxidation,) it was proper that the original should be of the same material, as affording a more perfect comparison. In speaking of this, he says;

"The adoption of brass as the metal for all standards, uniformly, is rather a consequence of old habits which gave it the preference, as the cheapest metal, not subject to prompt and very evident oxidation. Its compound nature might introduce differences in the ratio of its expansion by temperature, which, absolutely and scientifically speaking, would be a defect: but this variation is proved, by experience, to be too minute to have any effect upon the practical application to standards, within the limits of magnitude they generally have." — *Document* 299, p. 16.

There may be some question as to the propriety of this decision. But, in order to ensure the greatest uniformity, all the brass, used for the standards, has been made by the same process; the zinc having been obtained by distillation, and the copper exactly saturated by cementation. The brass, therefore, of the standards, is perfect free brass, tough, hard, and of uniform density.

For the standards of length, Mr. Hassler has adopted the form, in which the French toises were frequently made, "a measure cut to length with a matrix," the two fitting so closely, as to present a fine cut line, under the microscope. This form has the peculiar advantage, of showing always, from the looseness of the filling and consequent broadness of the contingent surfaces, any deterioration or misuse, which the standard may have suffered; while, when perfect, it unites all the properties of the *mètre au bout*, with those of the *mètre au trait*. It is, however, proportionably difficult in execution. The weights are frustums of cones, with knobs at their upper ends, and having the edges of their bases turned thin, to admit of a more delicate adjustment. The measures of capacity are cylinders of turned brass, with ground glass covers. Weights and measures of length have

already been standarded for the six principal custom-houses, and the remainder are in a state of forwardness.

On a review of the whole progress of this matter in the United States, we may, perhaps, find reason to congratulate ourselves that it was not undertaken at an earlier period, as, in that case, it is more than probable that the execution would not have been effected on a scale commensurate either with the object itself, or the science of the time. When we know, that balances are now constructed sensible to the hundredth of a grain, and that the microscopic comparison of measures of length is carried to the fifth decimal of the inch, and are aware that in a standard of near half an inch thick, Captain Kater discovered palpable differences, from drawing fine Wollaston wire under different portions of the bar, thereby producing different degrees of flexure, the difficulty and responsibility of a proper execution of measures, must be very evident. Had it been attempted at an earlier day, there would have been danger that we should have contented ourselves with a gross approximation, which would in a few years have required revision. As corroborative of this, we have been told, from undoubted authority, that when a new system of weights and measures was first thought of in this country, it was proposed by the chief of one of the departments, to intrust its execution to the director of the mint; it being at the same time well known, that of the latest gold coinage of the country, scarcely two pieces can be found of similar weight, or not differing by a quantity discernible in a broker's balance. The silver coinage is still more unequal, as all chemists, who have been in the habit of using the small pieces for weight, can testify.

We are also now better aware, from the minute accounts of such projects in the elder countries, of the means necessary to be taken for the preservation of the original and prime standards. If they should be kept as the English Exchequer standards were long kept, they will soon be uncertain and indeterminable. If, on the contrary, they be preserved as the French standards have always been, among the most important archives of the state, and never shown or touched except by men of science, they will be always of certain reference, and fully answer the object of their construction.